

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
14 March 2002 (14.03.2002)

PCT

(10) International Publication Number
WO 02/20941 A1

(51) International Patent Classification⁷: E21B 33/128

CH, CN, CO, CR, CU, CZ, DE, DE (utility model), DK, DK (utility model), DM, DZ, EC, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(21) International Application Number: PCT/NO01/00275

(22) International Filing Date: 29 June 2001 (29.06.2001)

(25) Filing Language: Norwegian

(26) Publication Language: English

(30) Priority Data:
20004509 8 September 2000 (08.09.2000) NO

(71) Applicant and

(72) Inventor: FREYER, Jan [NO/NO]; Gjerdesvollen 16,
N-4045 Hafrsfjord (NO).

(74) Agent: OSLO PATENTKONTOR AS; P.O. Box 7007 M.
N-0306 Oslo (NO).

(81) Designated States (national): AE, AG, AL, AM, AT, AT
(utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA,

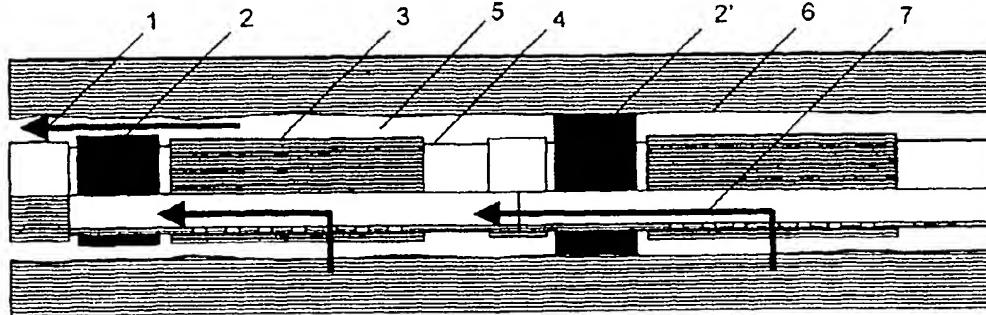
(84) Designated States (regional): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SI, SZ, TZ, UG, ZW), Eurasian
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,
IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CE,
CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

with international search report

For two-letter codes and other abbreviations refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette

(54) Title: WELL PACKING



(57) Abstract: Annular packer (2) arranged on the outside of a production tubing (1) said packer comprises a core (12) comprising elastic polymer swelling by absorption of hydrocarbons. The core (12) may be surrounded by an external mantle of rubber (10) which is permeable to hydrocarbons and may be equipped with a reinforcement (11). The core (12) swells by absorption of hydrocarbons and the packer (2) expands thus in order to seal the annular space (5) between the production tubing (1) and the well wall (6).

WO 02/20941 A1

BEST AVAILABLE COPY

Well packing

Field of the Invention

The present invention relates to a method of the nature as stated in the introduction of claim 1 for sealing of an annular space between a well wall in a production well for hydrocarbons and a production tubing, to a peripheral annular packer of the nature as stated in the claims 2-10, comprising an expandable element mainly consisting of rubber material, and to the expanding annular packer for application in said method

Background of the Invention

Completion of oil wells with sand control screens in open hole is a simple and reliable method by to complete a reservoir section. An oil well normally penetrates formations with varying production features, which, in spite of the fact that the sand control screens are closed on the inside, may cause that undesired well fluid by-passes on the outside of these and flow into the section. Therefore, it may be desired to control or shut off sections, which do not produce desired well fluid. This necessitates sealing the external annulus.

Today such seal is achieved by application of inflatable, open-hole packers (external casing packers), which are pressurised by injecting a fluid, which is confined by means of a valve system. As soon as the packer is pressurised, it is unable to follow movements in the face of the formation. Further it is sensitive to changes in temperature and pressure, and there are often considerable problems to achieve a complete seal. Another disadvantage is that the installation of the packer is expensive since well operations requiring complicated equipment are requisited.

From U.S. Patent 4.137.970 a packer is known with an element which by a chemical swelling process result in expansion of the element upon contact with water present in the well at the moment the packer is introduced to the bore hole. The 5 packer element is employed in mining, where water is to be drained from an aquiferous layer above a clay layer. The sealing consists of an expanding packer element. During such a swelling process the packer element will initially expand fast, before it expands slower. This is impractical 10 in an oil well, since the packer will expand before it is placed in the final operating position in the well. This implies that the packer may be put in the wrong position in the well, if it was to be employed in an application like the present invention and cause that the completion string 15 can not be inserted to its planned final position. Application of a medium swelling in water will cause the element to expand upon contact with all regular applied completion fluids or drilling fluids.

From U.S. Patent 4.633.950 polymer particles are known suspended in a special water based carrier fluid, which by circulation pumping shall be injected into a lost circulation zone. The patent does not relate to a packer element, but to a dispersion which shall trickle into porous/fractured rock. The features of such a dispersion implies that it 25 can not be held in place in order to form a solid plug in the annular space of the well. Further, the particles will upon contact with hydrocarbons expand very rapidly due to the large surface area of the small particles. Only minor impurities of remaining oil in the system will therefore 30 result in an undesired early expansion. Moreover, the particles in such a system will not expand at all if they do not contact hydrocarbons before the well is flowing back. This may lead to the polymer being produced with the produced fluids.

35 Most rubbers have a larger absorption capacity and faster swelling in an aromatic and/or naphtenic hydrocarbon than

in an aliphatic hydrocarbon. Most rubbers also have considerably less swelling in water based fluid than in an oil based fluid.

Generally base-oils used in drilling fluids have a higher portion of aliphatic (80-100%) constituents than produced hydrocarbons, normally having 35-80% aliphatic constituents. This implies that most rubbers will have a larger and faster expansion in produced hydrocarbons than in drilling fluids.

10 Purpose of the Invention

The purpose of the present invention is to enable completion of reservoir sections by complete annular seal, at the same time as the invention allows variations in operational parameters and geological conditions without changing the functionality of the invention. The packer will expand less while the packer is inserted into the well in a drilling fluid or completing fluid than by exposure to hydrocarbons produced from the formation.

This is achieved by the present method for sealing of an annular space between a well wall in a production well for hydrocarbons and a production tubing with a peripheral annular packer comprising an expandable element mainly consisting of rubber material characterised in that in said element a rubber is used which expands by absorbing hydrocarbons, and that the annular packer is inserted mainly by exposing the expanding element to hydrocarbons included in the product of the well.

Further the invention provides an expanding annular packer for use in the method for sealing of the annular space, comprising an expanding element consisting mainly of rubber material which is characterised in that the expanding element is directed to expanding mainly by absorbing hydrocarbons produced by the underground formation.

Further features of the invention are given in the claims 3-10.

Short description of the Figures

Figure 1 is a longitudinal section through an area of a production well illustrating the present invention.

Figure 2 is a longitudinal section of a production tubing with an annular packer according to the present invention.

Figure 3 is a section along the line III-III in Figure 2.

In the following, the invention is further described. The permanent annular packer 2 for use in hydrocarbon production wells, preferably oil production wells, is placed on the outside of a pipe 4, said packer expands by the core 12 swelling upon exposure for and absorption of hydrocarbons. The packer therefore seals the annular space 5 towards the well wall 6. The production well may be an open-hole well or a well with a casing, which is characterised in that the production tubing 4 is drawn in an open hole or that the production tubing 4 is drawn in a casing (not shown), respectively. Thus the annular space 5 consists of the external surface of the production tubing 4 and the bore hole wall, or the external surface of the production tubing 4 and the internal surface in the casing, respectively.

An oil stream 1 flows past a packer element 2 before the packer element 2 is expanded and sealing towards the well wall 6. A sand control filter 3 is attached to a production tubing 4. A packer element 2' is expanded and sealing towards the well wall 6 so that a well fluid 7 can not bypass the packer element in the annular space 5.

An external, protecting mantle 10 equipped with a reinforcement 11 surrounds a core 12 comprising elastic polymer, said coating works as a permeable membrane. The external

mantle 10 comprises a rubber with higher resistance and lower rate of diffusion towards hydrocarbons than the core 12. The packer element, which may consist of a mantle 10, reinforcement 11 and core 12, is placed on the outside of a 5 tube 4.

The packer 2 consists of a core 12 comprising an elastic polymer, e.g. EPDM rubber, styrene butadiene, natural rubber, ethylene propylene monomer rubber, ethylene propylene diene monomer rubber, ethylene vinyl acetate rubber, hydrogenized acrylonitrile-butadiene rubber, acrylonitrile butadiene rubber, isoprene rubber, chloroprene rubber or polynorbornene, said core is swelling in contact with and by absorption of hydrocarbons so that the packer expands. 10 The rubber of the core may also have other materials dissolved or in mechanical mixture, such as fibres of cellulose processed as described in U.S. Patent 4.240.800. Additional options may be rubber in mechanical mixture with polyvinyl chloride, methyl methacrylate, acrylonitrile, ethylacetate or other polymers expanding by contact with 15 oil. 20

An external, reinforced mantle 10 protects the core towards direct exposure to drilling fluid and hydrocarbons. At the same time the mantle 10 allows migration of hydrocarbons to the core 12 and swelling (and thus expanding of the packer). 25 The external, reinforced mantle 10 comprises rubber, for example acrylonitrile, hydrogenated nitrile, chloroprene, ethylene vinylacetate rubber, silicone, ethylene propylene diene monomer, butyl, chlorosulphonated polyethylene, polyurethane, ACM, BIMS or other types of rubber 30 having less expansion or slower diffusion than the core and a reinforcement 11, preferably fibre reinforcement, e.g. kevlar, said reinforcement reinforces the external mantle 10. An essential feature of the rubber in the mantle 10 is 35 that it has a swelling in drilling fluids, which is slower than the core 12. With "a higher resistance towards hydro-

"carbons" is here meant that the rubber only to a small degree swells upon exposure to hydrocarbons.

Several elastic polymers have a considerable absorption of hydrocarbons without absorption of water, and the polymers 5 in the present invention are predominantly hydrophobic. By immersion in a hydrocarbonaceous medium, hydrocarbons migrate into and through the external mantle 10 and further into the core 12, which is swelling upon absorption of these.

10 The present invention provides several benefits compared to state of the art. The packer adjusts continuously to variations in the movements of the formation or washouts of the borehole, which implies that better shutting off/sealing between reservoir sections may be achieved and undesired 15 well fluid can not flow past the packer element in the annular space. There is no need for well operations when installing the packer, which represents cost savings compared to today's methods for installation. The packer has no moving parts and is thus a simple and reliable device. The 20 packer expands faster and more in a produced hydrocarbon, than in a water based or oil based drilling fluid or completion fluid at the same temperature and will thus expand less when the packer is immersed in drilling fluid.

In another embodiment of the present invention, the core 12 25 is surrounded by an external mantle of rubber, e.g. a nitrile which is not reinforced.

In further another embodiment of the present invention, the core 12 is surrounded by an outer web which may be the reinforcement.

30 In a further embodiment of the present invention the core 12 is surrounded by an external mantle of rubber, e.g. a nitrile, said mantle in itself does not let hydrocarbons penetrate, but a small part 11 of the core 12 is exposed

directly to hydrocarbons through openings in the outer coating.

In an even further embodiment of the present invention the core 12 is not surrounded by an external mantle, but is exposed directly to hydrocarbons. In this aspect, the core 12 has a composition comprising elastic polymer with sufficient features to fulfil the desired functions of the packers.

What is claimed is:

1. A method for sealing an annular space between a well wall in a production well for hydrocarbons and a production tubing with a peripheral annular packer comprising an expandable element mainly consisting of rubber material characterized in that in said element a rubber is employed which expands by absorption of hydrocarbons, and that the annular packer (2) expands mainly by exposure of the expandable element to hydrocarbons included in the product of the well.
2. An expanding annular packer for use in the method according to claim 1, comprising an expanding element (2) mainly consisting of rubber material. characterized in that the expanding element is adjusted to expanding mainly by absorption of the hydrocarbons produced in the well.
3. An expanding annular packer according to claim 2, characterized in that the elastic polymer is selected from the group consisting of EPDM, styrene butadiene rubber, natural rubber, ethylene propylene monomer rubber, ethylene vinylacetate rubber, hydrogenated acrylonitrile butadiene rubber, acrylonitrile butadiene rubber, isoprene rubber, chloroprene rubber and polynorbornen.
4. An expanding annular packer according to claim 3, characterized in that the rubber of the core may have other materials dissolved or in mechanical mixture, such as processed fibres of cellulose or rubber in mechanical mixture with polymers expanding by contact with oil such as polyvinyl chloride, methyl methacrylate, acrylonitrile or ethylacetate.
5. An expanding annular packer according to any of the previous claims,

characterized in that the core (12) is surrounded by an external mantle (10).

6. An expanding annular packer according to claim 5,
characterized in that the external mantle
5 (10) is made of rubber which is permeable to hydrocarbons with lower diffusion coefficient or ability to expand in oil based drilling fluids and/or completing fluids than the core (12).

7. An expanding annular packer according to claim 6,
10 characterized in that the external mantle (10) completely or partly consists of types of rubber selected from the group comprising acrylonitrile, nitrile, hydrogenated nitrile, chloroprene, ethylene vinylacetate, silicone, ethylene propylene diene monomer, butyl, chloro-
15 sulphonated polyethylene, polyurethane, ACM, BIMS and other types of rubber having less expansion or slower diffusion than the core (12).

8. An expanding annular packer according to claim 5, 6 or
7 characterized in that the external
20 mantle comprises a reinforcement (11).

9. An expanding annular packer according to claim 8,
characterized in that the reinforcement (11) is a fibre reinforcement, for example comprising kevlar.

25 10. An expanding annular packer according to any of the preceding claims
characterized in that the expansion takes place in contact with hydrocarbons produced in the current oil production well.

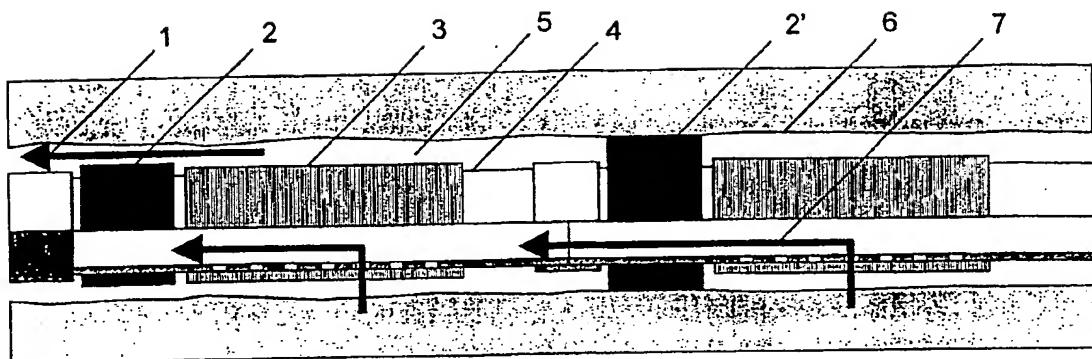


Figure 1

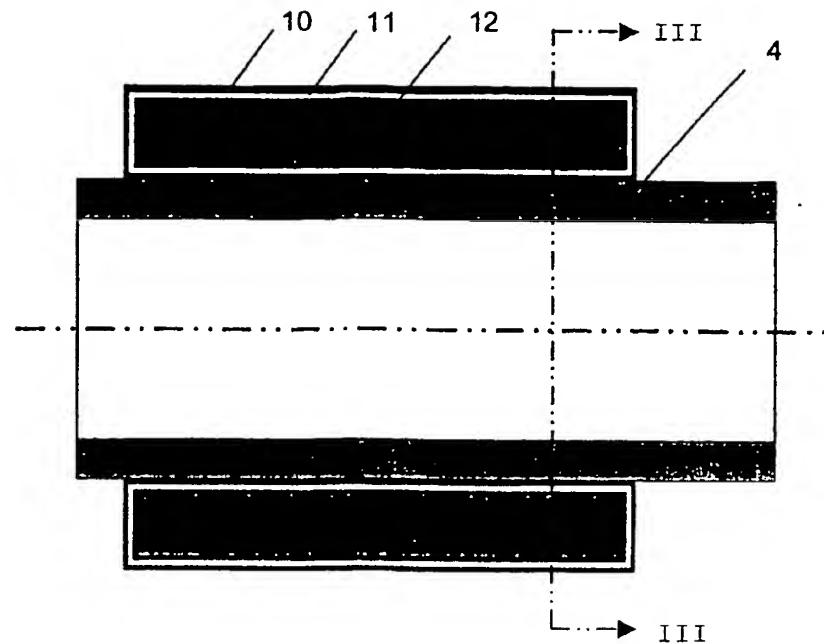


Figure 2

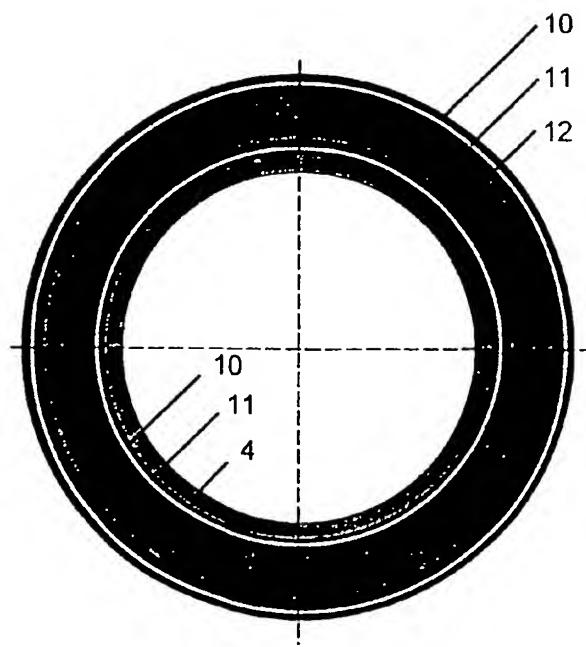


Figure 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 01/00275

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 33/128

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| A | US 4137970 A (G.P. LAFLIN ET AL), 6 February 1979 (06.02.79), the whole document -- | 1-10 |
| A | US 4633950 A (H.J. DELHOMMER ET AL), 6 January 1987 (06.01.87), the whole document -- | 1-10 |
| A | Patent Abstracts of Japan, abstract of JP 9-151686 A (OYO CORP), 10 June 1997 (10.06.97), the whole document -- | 1-10 |
| A | Patent Abstracts of Japan, abstract of JP -64764 A (NAKAYAMA NOBUO), 29 February 2000 (29.02.00), the whole document -- | 1-10 |

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

Date of mailing of the international search report

12 November 2001

13-11-2001

Name and mailing address of the ISA/
Swedish Patent Office
Box 5055, S-102 42 STOCKHOLM
Facsimile No. + 46 8 666 02 86Authorized officer
Uno Thörnborg / MRO
Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 01/00275

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|---|-----------------------|
| A | Patent Abstracts of Japan, abstract of JP 4-363499 A (OYO CORP), 16 December 1992 (16.12.92), the whole document --- | 1-10 |

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/10/01

International application No.

PCT/NO 01/00275

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|--|------------------|-------------------------|------------------|
| US 4137970 A | 06/02/79 | NONE | |
| US 4633950 A | 06/01/87 | NONE | |

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.